A Long-Term Study of Application of Joshi's External Stabilizing System in Displaced Intra-articular Distal End Radius Fractures

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Abstract

Background Fractures of the distal end radius are a common upper extremity fracture. Intra-articular distal end radius fractures are recognized as very complex injuries with a variable prognosis. The aim of the study was to assess the long-term functional outcome of patients treated with Joshi's external stabilizing system (JESS) for displaced intra-articular distal end radius fractures.

Materials and Methods A total of 170 patients with intra-articular distal end radius fracture were treated with JESS from 2014 to 2017. The patients were followed up at 2, 6 weeks, 6 months, 1, and 2 years (final) after the surgery. The assessment of pain, range of motion, grip strength, and satisfaction were assessed at 6 months, 1, and 2 years (final) follow-up and scored according to modified Mayo wrist scoring system.

Results The good and/or excellent results were found in 82.2% of cases. We observed that patients with age less than 50 years had greater prognosis as compared with patients with more than 50 years of age. Final outcome was also found better in males as compared with females at 6 months, 1, and 2 years postoperatively.

Conclusion JESS is an effective treatment technique for intra-articular distal end radius fractures in our community. On long-term follow-up of the patients treated with JESS for intra-articular distal end radius fractures, the functional and radiological outcomes were good with low complication rate.

Keywords
- Joshi's external stabilization system
- distal end radius fractures
- Mayo wrist score

Distal radius fractures are the commonest fractures in upper extremity.[1–3] Increasing incidence of these injuries may be attributed to an aged population (osteoporotic fractures) and the growing participation in outdoor pursuits (higher energy fractures).[4,5] Distal radius fractures have still remained a therapeutic challenge.[6] Collapse, loss of palmar tilt, radial shortening, and articular incongruity are frequent after closed treatment of unstable and comminuted intra-articular fractures of the distal radius, and these often result in permanent deformity, pain, and loss of function.[7] The closed reduction and immobilization of displaced fractures in a cast may lead to early displacement, hence skeletal fixation to maintain the reduction has been recommended.[8,9] The use of transfixing Kirschner wires (K-wires) with external fixation is recommended for severely comminuted fractures.[10] Open reduction and internal fixation (ORIF) using volar fixed-angle plates has also shown to be a valid treatment option for unstable, displaced distal radius fractures.

On the principle of Ilizarov, Joshi et al devised a simple external fixator (Joshi's external stabilizing system [JESS]), in the early 1990s which is cost effective, easily applicable, light weight, and needs minimum number of instruments for application.[11,12] However, it is not always that ligament traction obtained by means of the external fixator is enough to produce and keep reduction of the several fragments of very much comminuted fractures, which use to involve both

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radiocarpal and radioulnar joints. In these cases, it should be added of a percutaneous K-wire fixation, or after an open reduction of articular fragments with or without bone grafting.[13]

Pennig and Gausepohl[14] have recommended that external fixator to be used to restore the radial anatomy if three or more cortices show comminution on the anteroposterior and lateral films in conjugation with radial shortening of more than 5 mm and/or intra-articular involvement in the radiocarpal or distal radioulnar joint.

The purpose of this study was to investigate the efficacy of JESS in maintaining the reduction of unstable displaced intra-articular distal end radius fractures as well as to find out cases of collapse within second postoperative week and do secondary distraction in those cases and finally to assess the overall functional outcome in long term.

Materials and Methods

This study was performed from May 2014 to May 2017 on patients with displaced intra-articular distal radius fractures visiting our institute. Patients with any other associated injury/fracture, bilateral distal radius fractures, open fractures of distal radius, and associated head injury were excluded from the study. Written informed consent was taken from all the patients.

JESS distractor is a system based on ligamentotaxis of distal end radius fractures management. JESS consists of application of total of four pins in radius and second metacarpal connected by serrated connecting rod with provision for distraction. First two 3.5-mm Schanz pins were applied in radius 2 to 3 cm proximal to fracture. Then two 2.5-mm Schanz pins are applied in second metacarpal through JESS distractor holes (►**Fig. 1**). All the pins were checked under image intensifier to confirm for bicortical purchase and proper length. Distraction and acceptable reduction (►**Table 1**)[15] were achieved and confirmed in image intensifier. In few cases, reduction was supplemented with K-wires. Active finger mobilization exercise began on first postoperative day. Patient was discharged on third day and pin tract care was explained to patient. Patient was followed up at 2 weeks to check for pin tract discharge or loosening and check X-ray was done, if loss of radial height was seen, then secondary distraction was done to correct it (in these patients, delayed removal of distractor was done). At 6 to 7 weeks, postoperative X-ray was taken and then distractor removal was done after radiological sign of union. Then follow-up was done at 6 months, 1 year, and 2 years (final) to check for progress and final outcome. Outcome of patient was assessed using modified Mayo wrist score. The final scores of 80 to 89 were considered as good result and 90 to 100 were considered as excellent result.

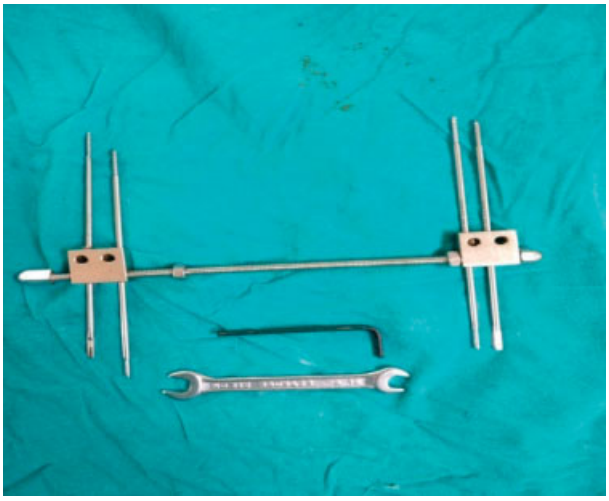

Fig. 1 Joshi's external stabilizing system.

Table 1 Guidelines for acceptable closed reduction

Radioulnar length	Radial shortening of < 5 mm at DRUJ compared with contralateral wrist
Radial inclination	Inclination on PA film ≥ 15 deg
Articular incongruity	Incongruity of intra-articular fracture is ≤ 2 mm at a radiocarpal joint
Radial tilt	Sagittal tilt on lateral projection between 15-deg dorsal tilt and 20-deg volar tilt

Abbreviations: DRUJ, distal radioulnar joint; PA, posterio anteriror.

Statistical Analysis

All the data were analyzed using SPSS 20. The scores at 6 months, final follow-up were compared using two-sided paired sample *t*-test. Score in different age groups and gender were compared using Student's *t*-test. The *p*-value of less than 0.05 was considered as significant.

Results

A total of 170 patients of displaced distal end radius fracture were treated with the JESS during the study period. Out of 170 patients, 105 (61.8%) were female and 65 (38.2%) were male.

As per the AO classification, 41 patients had type B1, 35 type B2, 37 type B3, 29 type C1, 17 type C2, and 11 type C3. The mean age of patients was 45.1 $\pm$ 11.3 years. The right hand was injured in 98 (57.7%) patients. Mean interval between injury and surgery was 1.8 days. The average operative time was 36 $\pm$ 8 minutes (►**Table 2**). In 57 cases, reduction was supplemented with K-wires, and it was used specifically in cases with isolated radial styloid fragment and cases with distal radioulnar joint subluxation which did not correct after application of distractor.

Mean duration of JESS application was 6.2 + 0.9 weeks. Mean time of radiological union was 6.2 + 0.9 weeks. Twelve patients developed pin tract infection which was managed successfully by antibiotic treatment. Swelling, inflammation, and occasional pain were observed in seven patients.

The good and/or excellent results were found in 82.2% of cases. There was significant decrease in pain and increase in

Table 2 Patient demographics

Age (y)	Mean 45.14 ± 11.27	
Gender	Female: 105 (61.8%) Male: 65 (38.2%)	
Right hand	98 (57.7%)z	
Mode of Injury	Fall: 75 (44.11%) RTA: 95 (55.88%)	
Average operative time	36 ± 8 min	
AO type	**Number**	**Percentage (%)**
A1	0	–
A2	0	–
A3	0	–
B1	41	24
B2	35	20.5
B3	37	22
C1	29	17
C2	17	10
C3	11	6.5
Total	170	100

Abbreviation: RTA, road traffic accident.

range of motion (ROM), grip strength, and activity at 2 years (►**Fig. 2**) when compared with 1 year (►**Fig. 3**) and 6 months (►**Fig. 4**) (►**Table 3**).

We compare the scores between two different age groups (group 1 with age less than 50 years and group 2 with age more than 50 years). We observed that only 84% of patients in group 2 had good or excellent result as compared with 89.1% in group 1 at final follow-up. We observed there was significant difference in pain, ROM, grip strength, activity, and final score in these two groups (►**Table 4**).

In four patients, loss of radial height was noted at 2 weeks and secondary distraction was done. The mean postoperative modified Mayo wrist score in male and female is shown in ►**Table 5**. Our study complications are as follows: 12 patients developed pin tract infection which was managed successfully by antibiotic treatment, but none of them converted to deep infections. Four patients developed complex regional pain syndrome which was managed successfully by conservative management. In nine patients, articular collapse was seen after the removal of JESS; the fixator was not prematurely removed in these cases and we could not identify any cause for collapse. ►**Fig. 5** shows radiological outcome and ►**Fig. 6** shows clinical outcome of a 68-year-old woman with displaced intra-articular distal end radius fracture treated with JESS.

Discussion

Different types of fractures may occur due to the anatomy of the distal radius. The successful use of external fixation requires careful assessment of fracture pattern, correct surgical techniques, supplemental fixation with K-wires, adherence to a postoperative protocol involving pin tract care, and early mobilization. Many external fixation devices are described to achieve reduction and fixation of the fragments without loss of position and acceptable functional results.[16] The ligamentotaxis is the basic principle in external fixator treatment.[9]

In our study, we used JESS fixator for treatment of displaced intra-articular distal end radius fractures which allowed sound fracture union with functional mobility. The good and/or excellent results were found in 82.2% of cases. There was significant decrease in pain and increase in ROM, grip strength, and satisfaction at 2-year follow-up when compared with 1 year and 6 months and minimal complications. Males and patients in age group <50 years had better result when compared with females and patients in age group >50 years. In four patients, loss of radial height was noted at 2 weeks and secondary distraction was done.

Often, intense physiotherapy is required to rehabilitate these patients.[17] The early mobilization of the wrist leads to normalization of blood supply, hastened functional recovery, earlier resolution of wrist swelling, and decreased joint stiffness.[18] The dynamic external fixators have been developed to provide mobilization of the wrist while reduction and fixation are maintained.[17]

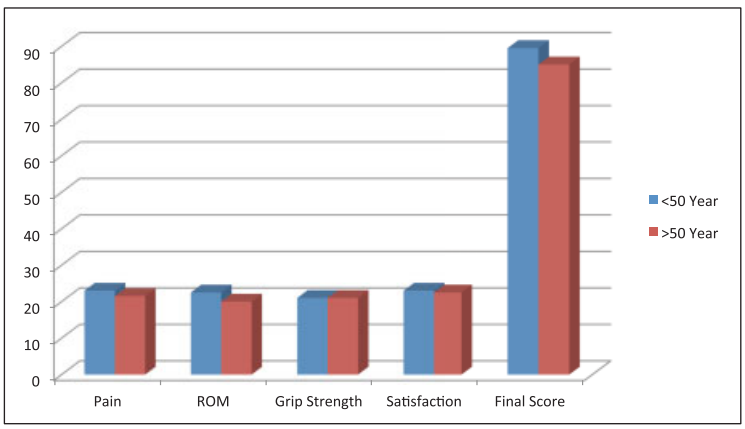

Fig. 2 Modified Mayo wrist score at 2 year. ROM, range of motion.

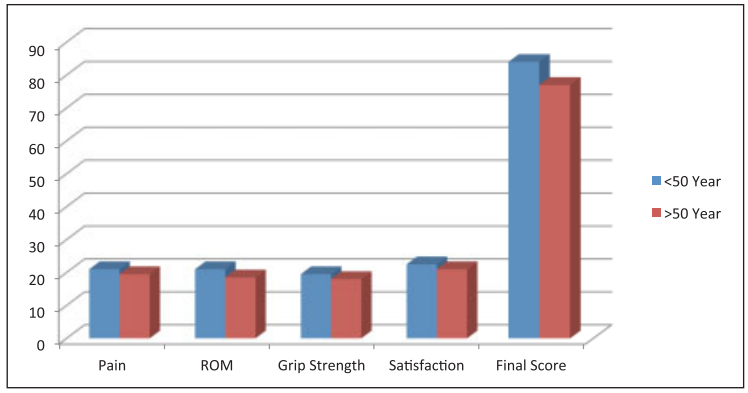

Fig. 3 Modified Mayo wrist score at 1 year. ROM, range of motion.

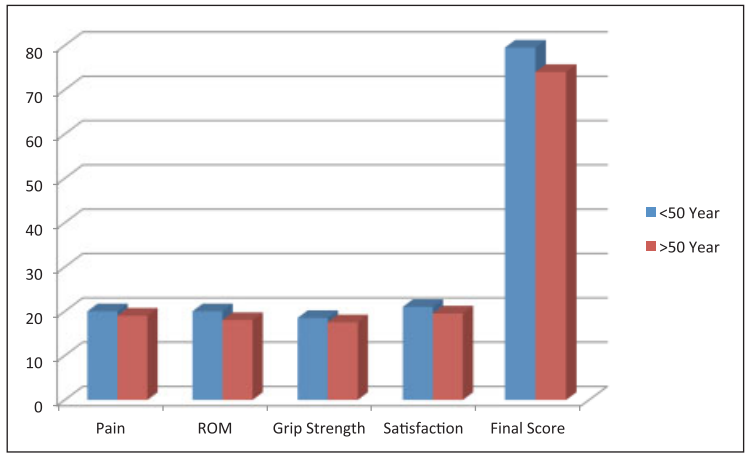

Fig. 4 Modified Mayo wrist score at 6 months. ROM, range of motion.

Table 3 Modified Mayo wrist score at each follow-up

Modified Mayo wrist score				
	At 6 month	At 1 year	At 2 year	*p*-Value
Pain	19.71 ± 2.50	21.93 ± 2.75	22.56 ± 2.70	0.0001
ROM	17.66 ± 5.23	20.58 ± 4.12	21.82 ± 3.10	0.0001
Grip strength	17.12 ± 2.85	18.80 ± 3. 12	20.18 ± 2.33	0.0001
Satisfaction	20.16 ± 1.56	22.88 ± 3.45	23.73 ± 1.77	0.0001
Final score	74.65 ± 12.14	84.19 ± 13.44	88.29 ± 9.90	0.0001

Abbreviation: ROM, range of motion.

Table 4 Modified Mayo wrist score of <50 years and > 50 years age groups

	Modified Mayo wrist score at 2 year (mean)	At 2-year follow-up good/excellent result
Age <50 years	89.40	89%
Age >50 years	84.00	84%
Overall	87.89	86%

Table 5 Modified Mayo wrist score of male and female groups

	Female	Male
Modified Mayo wrist score at 6 month	67.1 ± 14.2	80.64 ± 9.10
Modified Mayo wrist score at 1 year	77.2 ± 12.31	89.79 ± 4.88
Final modified Mayo wrist score	85.3 ± 8.29	93.32 ± 3.35

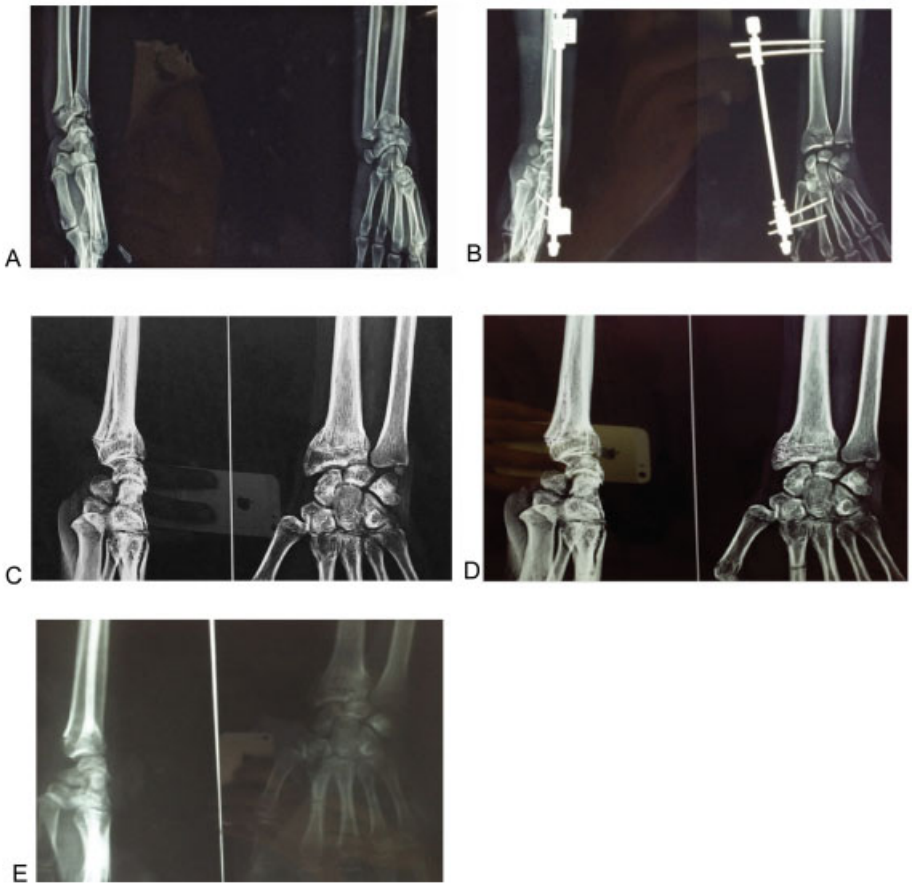

Fig. 5 Preoperative X-ray of wrist joint showing displaced intra-articular distal end radius fracture (**A**), immediate postoperative X-ray (**B**), 6-month follow-up X-ray (**C**), 1-year follow-up X-ray (**D**), and final follow-up X-ray (**E**).

Jenkins et al[19] performed a prospectively controlled study in which patients with a distal radius fracture were treated either by plaster or by external fixation. Ninety-four per cent of the external fixator group had a periarticular fixation. The external fixator proved more effective in holding the manipulated position and the radiological loss of union was minimal when compared with plaster group. Grewal et al[20] prospectively randomized 62 patients to open reduction and dorsal plate fixation versus external fixation supplemented with K-wire. The dorsal plate group had a significantly higher complication rate including pain, decreased grip strength, and increased tourniquet time; however, there was no difference in Short Form 36 or Disabilities of the Arm, Shoulder, and Hand scoring systems. Their recommendation was to avoid the use

Fig. 6 Functional results in a 68-year-old woman at final follow-up (2 years).

of dorsal plating. Kapoor et al[21] in their study on displaced intra-articular fractures of distal radius compared results following closed reduction and plaster, external fixation and open reduction with internal fixation, and in the final functional assessment (Sarmiento), the results were (1) plaster: 43% good and excellent, 50% fair, and 7% poor; (2) external fixator: 80% good and excellent, 20% fair and poor; and (3) ORIF: 63% good and excellent, 26% fair, and 11% poor. They recommended that displaced severely comminuted intra-articular fractures should be treated with an external fixator.

With the recent development of volar locking plates for the distal radius, fragment-specific fixation has emerged as an option. ORIF using volar fixed-angle plates has also shown to be a valid treatment option for unstable, displaced distal radius fractures, but when compared with JESS, volar plate requires open reduction, increased operative time, use of tourniquet, and on long-term follow-up, the results of JESS fixation are satisfactory.

Good results are seen with the use of external skeletal fixation in displaced intra-articular fractures. It maintains the radial length best due to sustained counter traction utilizing the principle of ligamentotaxis. Best results in severely comminuted fractures are seen with a fixator. The complications with this procedure are minimal with meticulous pin insertion and pin site care. No other study has documented long-term follow-up of results of JESS in intra-articular distal end radius fractures. Our study results are similar to other studies in term of outcome, but we had less complication.

In conclusion, external fixation with the JESS is a popular and effective treatment for intra-articular distal end radius fractures with low complication rate.

Conflict of Interest
None.

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